UCRL-JC-122286 Ext Abs

Adaptive Remediation Using Portable Treatment Units

Sally Bahowick, Richard Blake, Edwin Folsom, Maurice Hernandez,
Larry Kita, George Metzger, Tristan Pico
Lawrence Livermore National Laboratory

Summary

Lawrence Livermore National Laboratory (LLNL) is using adaptive remediation to cost-effectively optimize our environmental restoration strategy as more is learned. Adaptive remediation uses hydrostratigraphic analysis to gain a better understanding of the subsurface characteristics, hydraulic tests to optimize contaminant transport models, and Portable Treatment Units (PTUs) in addition to fixed facilities. Hydrostratigraphic analysis is an optimization tool that improves our ability to identify and target contaminant migration pathways, identify the relationship between plumes and source areas, and better define hydraulic capture areas. Hydraulic tests, performed with PTUs, provide valuable data about subsurface characteristics. As clean up progresses, PTUs can be moved to the appropriate extraction wells to optimize contaminant mass removal. PTUs can also be placed to support innovative treatment technologies such as steam injection and microbial filters. Construction of PTUs will reduce by one-half the capital costs of building the rest of the fixed treatment system planned in the Record of Decision (ROD). Regulatory agencies are receptive to the use of the PTUs because the same treatment technology is being used as in the fixed facilities. Using adaptive remediation, LLNL is more effectively implementing remediation plans, shortening cleanup time, and reducing project costs.

Site Description

LLNL is a research and development facility owned by the US Department of Energy and Operated by the University of California. The ground water near the Livermore site, which is located about 40 miles east of San Francisco, is used for drinking water and agriculture. In 1982, multiple plumes of volatile organic compounds (VOCs), predominantly trichloroethylene (TCE), were discovered in ground water beneath the Livermore site. LLNL was placed on the US Environmental Protection Agency's National Priority List in 1987. LLNL investigations identified the source areas including sites where solvents and other chemicals were known to be disposed of, where spillage from outdoor facilities occurred, and where releases from underground storage facilities and pipelines occurred. The identified compounds that exist in ground water at concentrations above the drinking water standards are VOCs, fuel hydrocarbons, chromium, lead, and tritium. The remediation area covers about 1.5 square miles and the contaminants are distributed within a thick, complex sequence of alluvial sediments.

Remediation Plan

As presented in the ROD in 1992, a pump and treat strategy is the remedial alternative selected by DOE, LLNL, and the stakeholder, regulatory agencies and public to prevent further migration and achieve the most rapid cleanup. Ground water is extracted throughout the contaminated area and treated at the surface using UV/Oxidation or air stripping with granular activated carbon (GAC) to prevent any measurable air emissions. Ion exchange is the selected treatment technology for chromium. This phased cleanup plan utilizes 18 initial extraction locations connected to 7 ground water treatment facilities and was conservatively estimated to take 50 years to reduce contaminant concentrations to Maximum Contaminant Levels (MCLs).

Phased installation of extraction wells allows the analysis of performance, so later extraction wells can be more optimally targeted. This approach is being used to remediate the portion of the plume which has migrated offsite to the City of Livermore at the south west corner of LLNL and to capture the rest of the plume along the western boundary so it does not migrate to the City of Livermore. LLNL has stopped the down gradient migration and decreased VOC concentration of the off-site plume. The "picket fence" of extraction wells along the western edge, to be completed in February 1996, will prevent the migration of the on-site plume to the City of Livermore. Capture analysis is being used to determine if and where additional extraction wells are needed along the western border.

There are 5 ground water treatments facilities currently in operation which are connected to a total of 22 extraction wells. As of August, 1995, 715 million liters of water have been pumped removing an estimated 75 kilograms of VOCs. Since the ROD, LLNL has been evaluating alternatives to reduce costs and cleanup time. Alternatives under consideration include building on good stakeholder working relationships and the changing regulatory climate that can make earlier, cheaper site closure possible. Regulatory agencies are working with us to reduce paperwork and reporting, allowing for a more cost-effective cleanup with the same budget. The State of California's new containment zone policy should allow earlier closure of some sites through more rational cleanup standards. This should allow us to cease sitewide remediation at higher contaminant levels than currently required by the regulatory agencies.. Adaptive remediation is being used to more effectively implement remediation plans, improve cleanup time, and reduce overall project costs.

Adaptive Remediation

The Livermore Site ROD describes fixed treatment facilities with pipelines connected to the extraction wells. A strictly mechanical implementation might assume perfect knowledge of the subsurface and not allow for changes in plume geometry or location. To understand the hydrogeologic factors that control these changes and site-specific flow and transport of contaminants in the subsurface, LLNL uses a characterization technique called hydrostratigraphic analysis. This technique, required to achieve cost-effective ground water cleanup, divides the subsurface into hydrostratigraphic units (HSUs) based on a detailed analysis of chemical, geological, and aquifer test data. Seven HSUs have been identified at LLNL, which are defined as sedimentary sequences whose permeable sediments show evidence of hydraulic communication. HSU analysis is used to define the hydraulic interconnectedness of the contaminant bearing strata, and map the geometry of the specific contaminant plumes. The boundaries that divide the HSUs consist of low permeability sediments which act as hydraulic and contaminant flow controlling features in the strata. Once defined, the HSUs are a useful decision support tool needed in the design of the initial configuration of the extraction wells fields needed for pump and treat remediation. Hydraulic tests and initial remediation further define the hydrostratigraphy of the site, and as more information is gathered and the plume locations and geometries change with remediation, the optimum extraction locations change. A rigidly fixed system would incur further cost for reconfiguration such as adding pipelines to new extraction well locations. Using PTUs instead, the treatment facility can simply be transported to a new extraction location. HSUs have been a useful management tool for optimizing site-wide remediation by improving our ability to identify and target contaminant migration pathways, delineate individual plume geometries, identify the relationship between plumes and source areas, and better define hydraulic capture areas.

A hydrostratigraphic conceptual model of the VOC plume near source areas in the interior of LLNL has been used to refine the remediation design which will capture and prevent further migration of this portion of the plume. Hydraulic testing with PTUs will provide data to further refine the conceptual model. Hydraulic interconnection between or within permeable layers is measured directly from response to ground water pumping. The improved hydrostratigraphic model will be used to optimize the targeting of extraction locations. The number of extraction and monitor wells necessary for performing and monitoring cleanup is minimized resulting in a shorter cleanup time and reduced cost.

Portable Treatment Unit

The PTU is a portable, less-costly treatment facility to be used for hydraulic tests and contaminant mass removal throughout LLNL's Livermore Site. An entire PTU is contained within a 20 ft long by 8 ft wide by 9 ft high cargo container. The primary treatment components of the system are a particulate filter, an air stripper, and a GAC canister. The PTU's hydraulic range of 1 to 45 gpm is dictated by the air stripper. The operational flow rate is dependent on the concentration of VOCs in the ground water being treated. For influent TCE concentration of 2000 ppb, the PTU will be able to treat ground water up to 20 gpm, with the effluent water containing less than the detection limit (0.5 ppb) of VOCs based on field tests using LLNL ground water. At a flow rate of 45 gpm, the maximum influent concentration that can be treated to non-detect is approximately 100 ppb. The facility can be run off utility power or be powered by a 40 KVA diesel generator.

Up to three wells can be connected to the PTU influent. The influent ground water travels through electro-magnetic flow meters, where the flow rate is monitored and recorded by the Facility Control System (FCS). An injection point is provided for polyphosphate to control calcium carbonate scaling. The water travels through a particulate filter, where particulate and sediments are removed. The filter elements are rated to a nominal 5 microns and are contained in a stainless steel housing. The filtered water travels through a stainless steel air stripper of low-profile, stacked-tray design. Water enters from the top, and is aerated while it flows down through a series of trays.

The treated water collects in a sump at the base, and is pumped out in batch mode by the stripper discharge pump through the exit line to a nearby ditch. This commercially available air stripper contains its own blower, sump pump and controls. The VOCs in the air stream are adsorbed onto a vapor-phase granular activated carbon canister. If hexavalent chromium treatment is necessary, the water is diverted after the air stripper through two ion exchange columns plumbed in series. The water flows through a pH monitor and is discharged in a nearby drainage ditch. The ion exchange resin in the columns will be regenerated at an existing fixed ground water treatment facility.

LLNL engineers have combined object oriented modeling and design methods, rigorous validation and verification procedures, human factors engineering, and application of standard instrumentation and software to produce the FCS for the PTU. The system adheres to strict fail-safe design standards, is user friendly, and can be operated unattended. The FCS can be adapted to future changes in the process such as those due to well field management and remediation experiments. It is designed to provide extensive data and status reports and to maximize the efficiency of maintenance support over the facility lifetime. Implementation and testing efforts for installing the FCS were reduced by at least a factor of two because knowledge gained from previous system design was utilized instead of starting from scratch. These savings were realized because of the high degree of modularity that has been built into the control system design. Cost savings in future PTU implementations will be even greater, as the identical software can now be used in each of them. It is expected that this design philosophy and approach will result in significant savings in maintenance, operations, and training costs over the lifetime of these systems.

PTUs will be used to conduct the hydraulic tests that may take from days to months per test. A portable generator will be used to power the PTU for hydraulic testing. When a well is chosen for long term remediation, the PTU will be connected to utility power. As the clean up progresses, the PTUs can be moved to the appropriate extraction wells. PTUs can also be placed to support innovative treatment technologies such as steam injection, biotic or abiotic filters.

The cost of equipment for the PTU is approximately $100K. The estimated cost for complete construction using an outside firm is approximately $200K. PTU construction will reduce by one-half the capital costs of building the rest of respective conventional treatment and pipeline systems planned in the ROD. This does not count the additional costs necessary to reconfigure a conventional pipeline system as the plume changes and the remediation design updated. The regulatory agencies are receptive to the use of the PTUs without a ROD change. The PTUs augment the adaptive remediation in our efforts to bring the site cleanup to completion in the shortest time possible.

Work performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under Contract W-7405-Eng-48.